United States Nuclear Regulatory Commission

RIC 2006

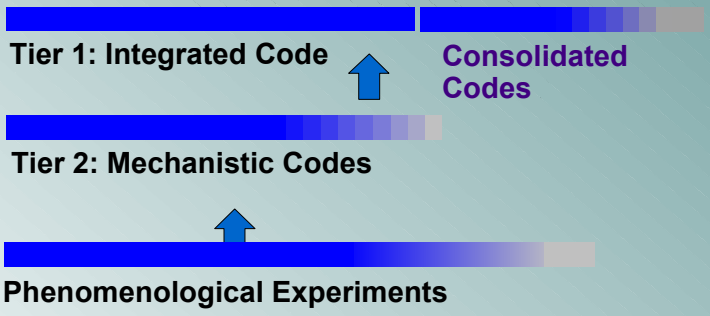
Session T2BC

Severe Accident Research Changing Landscape

S. Basu
U.S. Nuclear Regulatory Commission
Office of Nuclear Regulatory Research

March 7, 2006

Nuclear Safety Technology Evolution

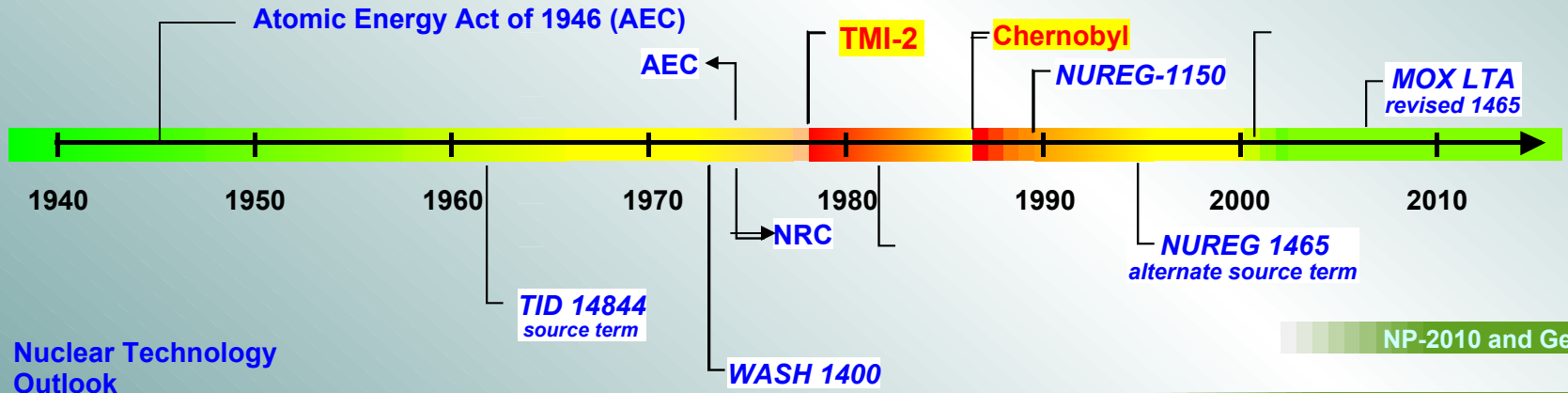


Fundamental Research ▸ ▸ Regulatory Products

Expert Judgment ▸ Phenomenology ▸ Analytical Tools

Risk Informed Regulation

Regional/National → Cooperative/International



Nuclear Technology Outlook

- Optimistic
- Guarded
- Pessimistic

NP-2010 and Gen-IV

Emerging Issues

MOX, High Burnup, Life Exension

Changing Landscape

- Expert Judgment to Phenomenological Research
  - Heuristic reasoning based on related experience
  - Bounding analysis
  - Phenomenological experiments
  - Analytical tools
- Fundamental Research to Regulatory Products
  - Understanding of basic phenomena
  - Development of models and codes
  - Plant safety analysis
  - Issue resolution and regulatory applications
- Regional to Cooperative Research

Selected Examples

- Alternative Source Term (AST)
  - Regulatory application of NUREG-1465 (since 1995)
    for DBA analysis
  - Embodiment of knowledge on FP release and transport
  - Knowledge gained from extensive fission product research
  - Knowledge transported into MELCOR
  - AST applied to operating reactors and new reactor designs
  - Cooperative program PHEBUS providing confirmatory data
  - VERCORS providing data for AST for HBU and MOX
  - Supplement to NUREG-1465 for HBU/MOX in progress

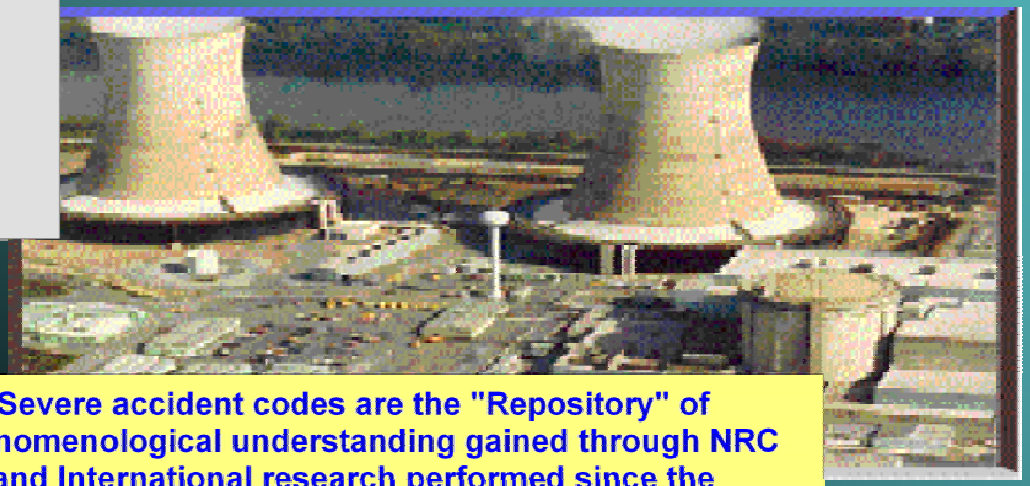
Selected Examples

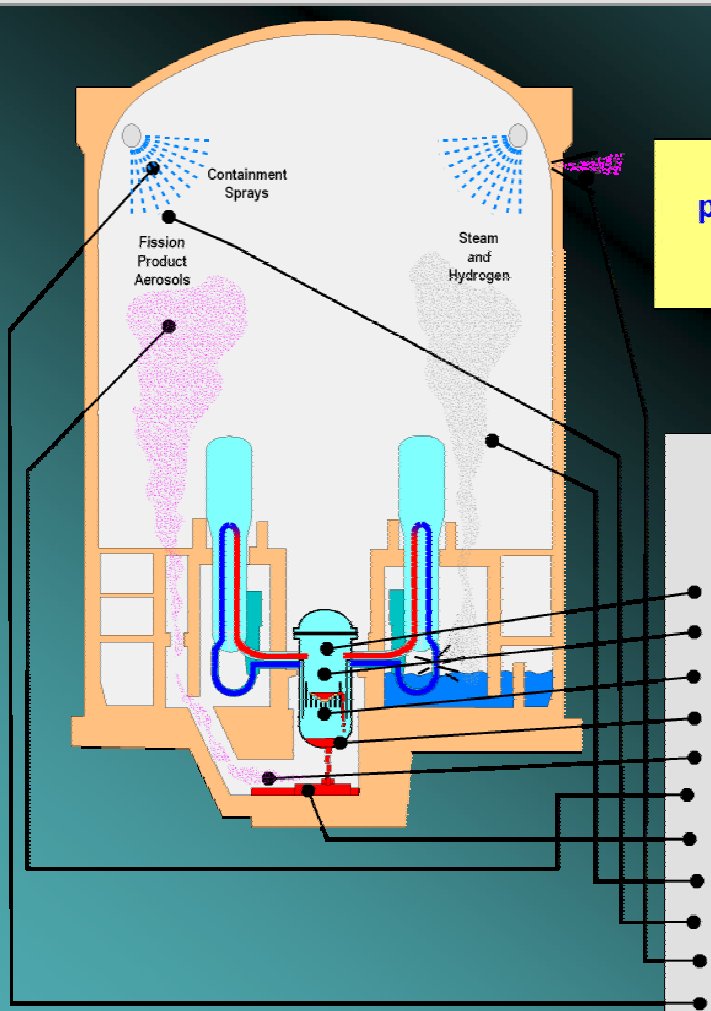
- Steam Explosion Risk
  - Issue identified in WASH-1400 and ZIP study
  - Expert judgment and bounding estimates in early days
  - Fundamental research leading to SERG-1 deliberation on alpha-mode issue in 1985
  - National and cooperative (international) research activities
  - Further quantification of risks leading to SERG-2 (1995): resolution of the issue from risk perspective
  - Closure on steam explosion-induced lower head failure

Selected Examples

- Core Debris Coolability
  - In-vessel core retention for high power reactors
  - LHF leading to core-on-the-floor, SAMG effectiveness
  - National and cooperative research activities in 80s & 90s
  - ACE program provided data on 1-D CCI
  - MACE program inconclusive on coolability issue
  - MCCI program generated promising results
  - MCCI data used for model and code development
  - Further work in progress

Modeling and Analysis of Severe Accidents in Nuclear Power Plants





Severe accident codes are the "Repository" of phenomenological understanding gained through NRC and International research performed since the TMI-2 accident in 1979

***Integrated* models required for self consistent analysis**

Important Severe Accident Phenomena

	MELCOR	CONTAIN	VICTORIA	SCDAP RELAP 5
Accident initiation	■			■
Reactor coolant thermal hydraulics	■			■
Loss of core coolant	■			■
Core meltdown and fission product release	■		◪	■
Reactor vessel failure	■			■
Transport of fission products in RCS and Containment	■	■	■	
Fission product aerosol dynamics	■	■	■	
Molten core/basemat interactions	■	■		
Containment thermal hydraulics	■	■		
Fission product removal processes	■	■	■	
Release of fission products to environment	■	■	■	
Engineered safety systems - sprays, fan coolers, etc	■	■		
Iodine chemistry, and more	■			

Regulatory Use of Severe Accident Research